Lightning Fire Ignition Patterns in Yosemite National Park

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Abstract

FIRES IN YOSEMITE NATIONAL PARK BURN ACROSS THE LANDSCAPE IN MANY VEGETATION TYPES and elevation zones. Fire records dating from 1930 to 2010 have been used to determine the spatial distribution of lightning fire ignitions in the park. This investigation involved conducting a density analysis of all lightning ignited fires in the park to evaluate potential patterns within the landscape. When lightning does ignite fires, park managers use fire management units to prioritize which fires to manage or to suppress. However, the park is investigating removing the fire management unit boundary which dictates management action to bring decision making into congruence with current federal wildland fire policy. Assessing large landscape areas to determine whether or not to allow lightning ignited fires to burn will be paramount in this process. The following analysis will provide park managers with a means to prioritize management of ignitions based on the historic distribution of starts, the time since an area last burned, the time of year of the ignition, and where the ignition is located.

Introduction

Yosemite National Park covers 747,955 acres of the central Sierra Nevada in California, and its elevation varies from 2,000 feet in the west to 13,000 ft along the crest of the range. Along the elevation profile while travelling west to east, distinct vegetation types can be seen. Lower montane forests occur between 2,000 and 6,000 ft, upper montane forests from 6,000 to 8,000 ft, and subalpine forests from 8,000 ft to tree line, at 11,000 ft.

The Mediterranean climate of Yosemite is characterized by warm, dry summers and cool, wet winters, with precipitation primarily occurring between November and April. However, a monsoonal flow from the southeast, south, and southwest creates numerous thunderstorms and is responsible for lightning and rain in the summer. At the lower elevations, where burnable vegetation is abundant, lightning is less frequent. The converse is true for the higher elevations: abundant lightning, sparse vegetation (van Wagtendonk and Cayan 2008).

Because the Sierra Nevada has an extensive history of lightning strikes and subsequent fires (van Wagtendonk et al. 2002, van Wagtendonk and Fites-Kaufman 2006, van Wagtendonk and Cayan 2008), managers must consider factors, in addition to ecology, when deciding whether to

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suppress a fire. In 1972, a prescribed natural fire program was established in Yosemite, establishing the opportunity to manage lightning ignited fires, allowing them to burn under prescribed conditions (van Wagtendonk 2007). Yosemite National Park's extensive fire records (1930 to the present) have facilitated studies of the spatial distribution of lightning fire ignitions (van Wagtendonk 1994, van Wagtendonk and Davis 2010). This analysis builds on this research by addressing spatial density patterns of lightning ignitions.

In Yosemite, lightning ignitions occur along the western boundary of the park, in the lower mixed conifer forest. The majority of this area, however, falls in the Suppression Unit of the park, which is also in the most altered condition class (fire regime condition class, FRCC) or highest fire return interval departure (FRID) class. If a lightning ignition occurs in this management unit, Yosemite is bound by its fire management plan (FMP) to suppress the fire. In order to return fire to the landscape, and thereby reduce fuel build up within the Suppression Unit, the park is obligated to use prescribed fire. It becomes increasingly difficult to conduct large, landscape-level prescribed burns, and park managers have begun to evaluate its FMP to decide whether the Suppression Unit boundary (except around communities and infrastructure) should be removed. Yosemite would still evaluate each ignition based on fire history, time of year, availability of fire management resources, location, and amount of quality planning that has been accomplished.

Methods

Ignition distribution. Fire data from Yosemite National Park's GIS database were used to assess when and where fire ignitions occurred. These data are updated annually at the completion of the fire season, and are added to the database, which dates back to 1930. Actual ignition point location data have been collected by fire personnel using GPS for a number of years in Yosemite. However, for historic fires without accurate location data, the center of each fire perimeter was calculated in GIS. The lightning ignited point database was used for the spatial analysis of lightning fire ignition patterns. Additionally, this ignition point database was used to determine which fires were suppressed, and which were managed. Within the database, fire size was queried to determine how many acres were burned under each of two varying management strategies. The dataset was split into two groups, 1930 to 1971, and 1972 to 2010, because a change in fire management policies allowed park managers to allow lightning caused fires to burn, beginning in 1972, if the ignition occurred under prescribed conditions. The data were analyzed within these two groups as well as in totality.

Density analysis. The ignition point dataset was processed in a density analysis application. For each ignition, the analysis determined how many other ignitions were within 2 km. The resultant density was calculated, and displayed in ignitions per square kilometer.

Results

Ignition distribution. Between 1930 and 2010, a total of 3,199 lightning fires ignited, and they burned 197,027 ac within Yosemite National Park (Table 1; Figure 1). The result was an average fire size of 61.6 ac. However, before 1972, 1,340 fires burned 7,689 ac. This represents 42% of all ignitions, but only 4% of the total acres burned. The average fire size during this 42-year period decreases to 5.7 ac. All fires were suppressed per the management policies of the time.

Between 1972 and 2010, an additional 1,859 fires were detected, and they burned 189,338 ac. Therefore, in the past 39 fire seasons, the lightning ignitions, comprising just 58% of the total from 1930–2010, burned 96% of the total acres burned sine 1930. The average fire size in the last 39 seasons increased to 101.8 ac. Of these fires, 1,151 were suppressed either due to location, time of year, or availability of fire resources. This represents 36% of all fires, and 62% of fires between 1972 and 2010. These suppressed fires burned 83,280 ac (42% of the total acres burned, and 44% of acres burned since 1972) resulting in an average size of 72.4 acres. Seven-

Fire management period	Number of fires	Percent 1972-2010	Percent 1930-2010	Area burned (ac)	Percent 1972-2010	Percent 1930-2010	Ave size (ac)
1930-1971	1,340		42	7,689		4	5.7
1972-2010							
Suppressed	1,151	62	36	83,280	44	42	72.4
Managed	708	38	22	106,058	56	54	149.8
Sub total	1,859	100	58	189,338	100	96	101.8
Total	3,199		100	197,027		100	61.6

Table 1. Number, percent, and area burned by lightning fire ignitions for the period before and after the management policy change.

hundred-eight fires were managed for resources objectives between 1972 and 2010, and burned 106,058 ac. These managed fires represent 22% of all fires and 38% of fires between 1972 and 2010. They burned 54% of all acres and 56% of the acres since 1972. The average fire size of these managed fires grew to 149.8 ac.

Density analysis. Areas with a high density of lightning ignitions are apparent in Figure 2. Ridge tops with burnable vegetation in the western portion of the park are locations where multiple lightning ignitions have occurred. These areas are relatively higher on the landscape, and did not burn in the past 81 years. The surrounding fuels of the lower montane vegetation zone have become abundant due to fire exclusion, and are receptive to lightning-caused fires under the right conditions (van Wagtendonk and Fites-Kaufman 2006). Other areas of interest are vegetated, unglaciated ridges in the north-central part of the park. Areas of low density are equally visible in Figure 2. Deep, glaciated, granite valleys show few, if any, lightning ignitions.

There are, however, two areas that have low densities, despite being surrounded by areas of higher density. These areas are located near the middle of the park, and not near the crest (where ignitions are rare), nor are these areas deep valleys, where lightning is less likely to strike, much less ignite, a fire. Factors such as slope, elevation, vegetation type, and density were all assessed to determine why these areas have a low incidence of lightning ignitions. However, one factor, snow duration, seemed to influence the low ignition density result.

Discussion. Yosemite manages fire according to its 2004 fire management plan/environmental impact statement (FMP). Specifically, the park has two management units: Suppression and Managed Fire (NPS 2004). If lightning ignites a fire within the Suppression Unit, the park will immediately suppress it, using the appropriate management response strategy (NPS 2004). In the Managed Fire Unit, lightning-ignited fire would be the primary tool used to meet ecological target conditions (NPS 2004). Therefore, in order to treat fuels in the Suppression Unit, the park is mandated to use prescribed fire to achieve that objective because other mechanical methods to remove fuels are not permitted in the wilderness portions of the unit.

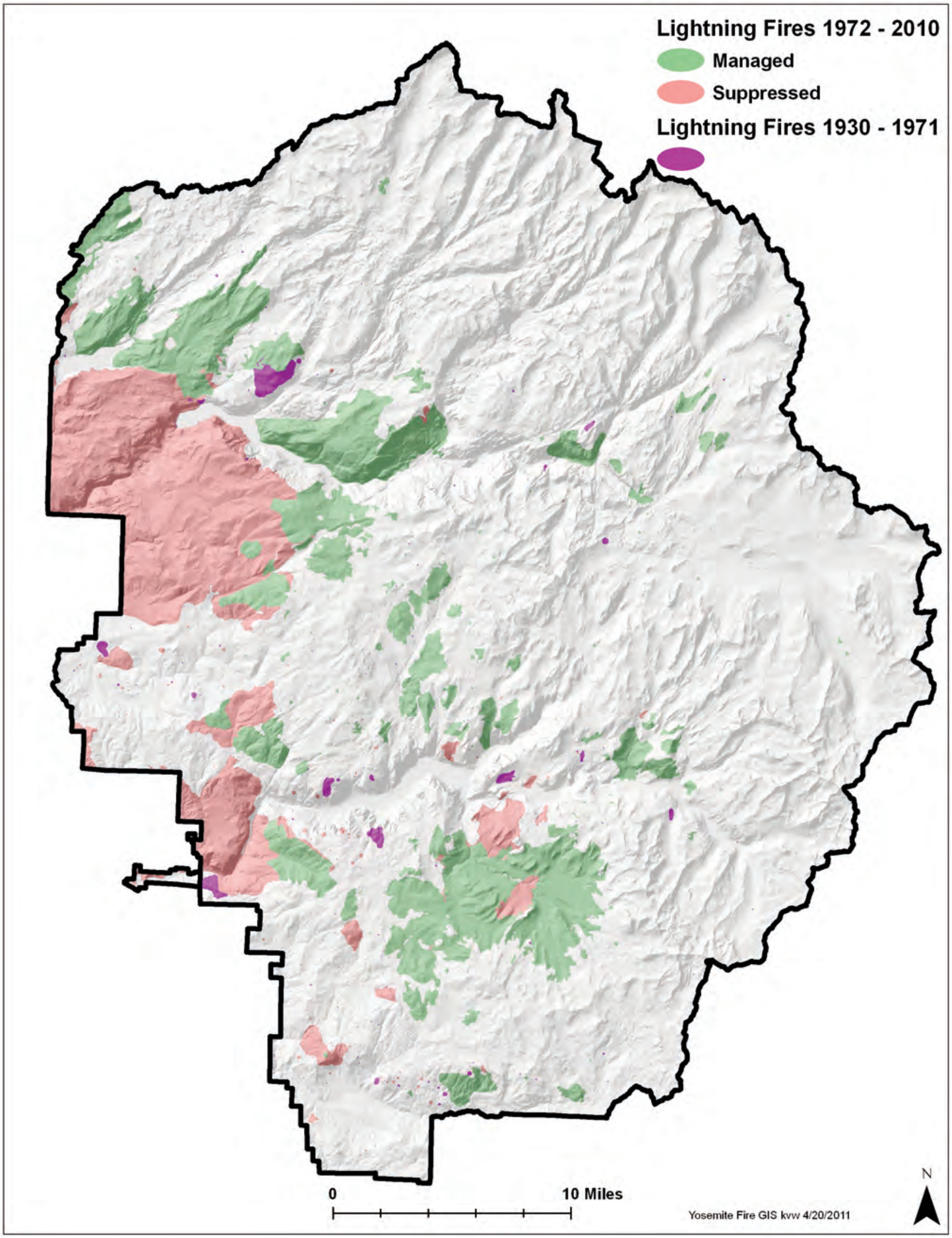

Figure 1. Lightning fire history for Yosemite National Park. The purple areas show the 7,689 acres that burned from 1930 to 1971. The pink areas represent the 83,280 acres that were suppressed and the green areas symbolize the 106,058 acres that were managed from 1972 to 2010.

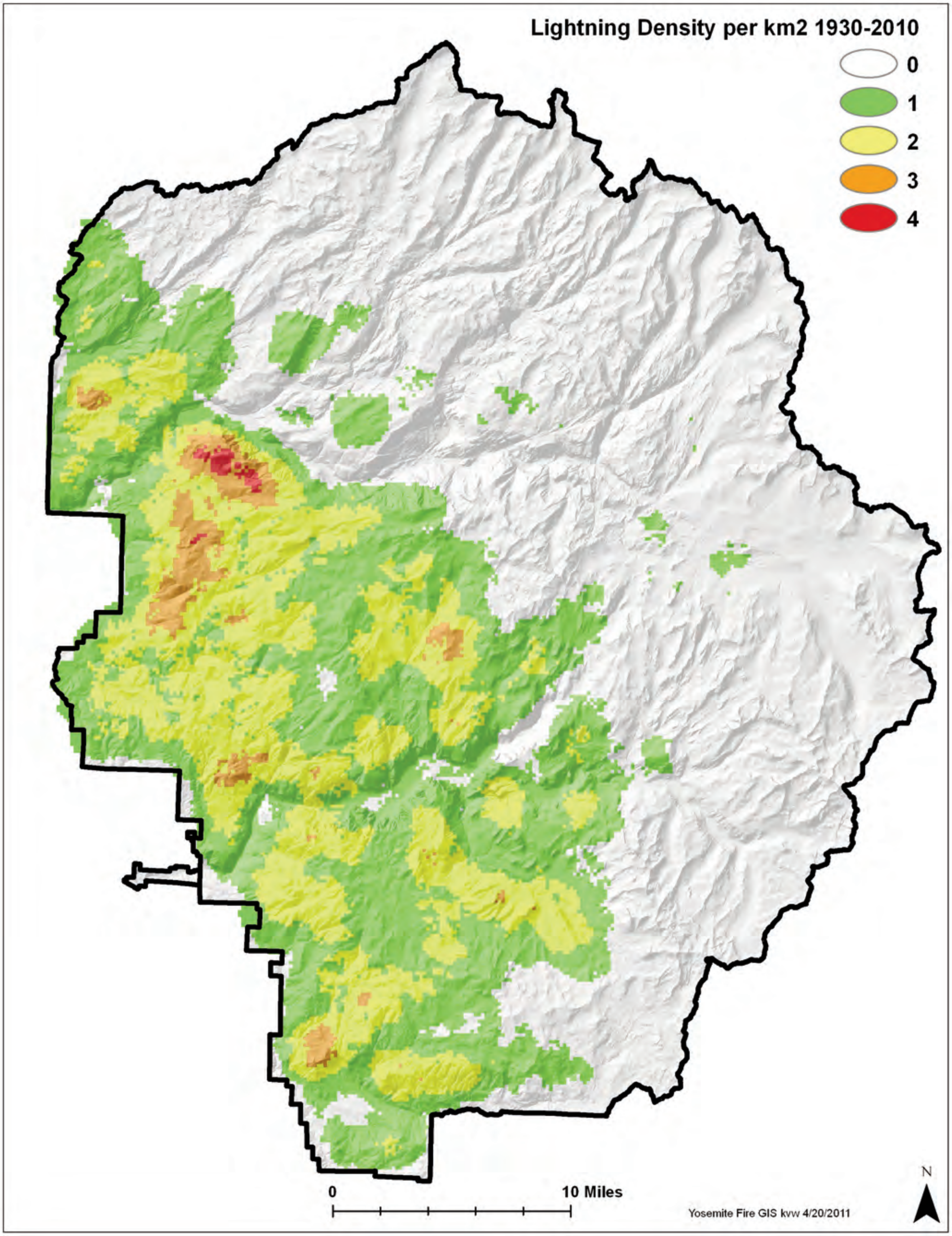

Figure 2. Lightning fire ignition density. The green areas represent low ignition density, and the red symbolizes areas of high density. Density is categorized as number of lightning fire ignitions per square kilometer.

As shown by the ignition and density data, the Suppression Unit receives significant lightning. Given that in this unit, the park would manage lightning fires for the single objective of putting them out, it would follow that the park should use prescribed fire to treat fuels and return fire to the Yosemite landscape. However, when looking at the prescribed fire history in Figure 3, this simply has not been happening on the scale needed to treat large areas. The park is suppressing lightning fires and is also not prescribe burning. Had the park allowed some of the lightning fires to burn, fuels could have been reduced (van Wagtendonk and Davis 2010). Additionally, each time the park suppresses a fire, there is an impact to the landscape, and a missed opportunity to break up the continuity of fuel loading and complex forest structure. Had a few of these fires been allowed to burn under prescribed conditions, future fires may have burned into the fire scars, and required fewer fire fighters and equipment, less risk, and environmental impacts from suppression. This strategy is how the park does manage fires outside of the Suppression Unit and there are numerous examples of where previous fire history influenced fire spread, intensity, and area burned.

Indeed, could Yosemite remove its Suppression Unit altogether? The park would still evaluate all fires, and employ suppression tactics near the communities of Wawona, Foresta, Yosemite Valley, El Portal, and the infrastructure at Hetch Hetchy, but outside of these identified wildland urban interface (WUI) areas, lightning would be used as the primary tool to restore fire to its natural ecological roll in the fire-adapted ecosystem of the Sierra Nevada. Yosemite, though, could suppress any fire, depending upon weather, fuels, topography, national and state preparedness levels, and time of year. But, by removing the Suppression Unit, the park would be able to manage landscape level fires through lightning, and reach targeted treatment acres as directed by the FMP. Additionally, given that the fuels projects outside of the WUI will only receive 10% of potential funding, leaving lighting as the only option to manage fires outside of WUI, this would be a way to treat fuels naturally. For example, the park conducted a 210 ac burn in 2010, and is funded for another 200 ac in 2011. While these projects are designed to protect the WUI areas, they do not meet the broader ecological objectives that landscape-wide prescribed or lightning ignited fire would achieve.

There are thousands of acres of the park that have missed more than 3 fire return intervals; however, the data and analyses show that these areas do indeed get lightning. The park, therefore, could utilize lightning ignitions to restore landscape complexity that would allow fires to "self organize," as we've seen in the Illlilouette basin. If multiple starts occurred, these previously unburned areas within the old Suppression Unit could be prioritized over previously-burned higher elevation areas. This would require a tremendous amount of planning to ensure the completion of a successful project. If the park were to move away from prescribed burn units, and utilize watersheds as planning units, the park could identify areas in the lower mixed conifer that receive frequent lightning, and use existing roads, trails, ridges, drainages, and previous fires as control points, but not boundaries. In 2009 the park managed the Grouse lightning ignited fire in such a way that used existing fire handline, the Wawona and Glacier Point roads to manage a lightning fire. Once the boundaries were established, the park was able to burn over 3,000 ac.

Inter-agency collaboration with the Forest Service would be essential if Yosemite were to move forward with this idea of using watershed boundaries as planning units. The western boundary between Yosemite and the Stanislaus and Sierra National Forests is made up of straight lines, and is not ecologically meaningful, nor is it realistic to manage fire along it. Other stakeholders, such as gateway communities, and local and regional air quality control districts, would have to agree to such a proposal before the park could go ahead with it. Agreement from all interested parties is the way to move forward, and is essential as the park strives for transparency in how it manages fires on its landscape.

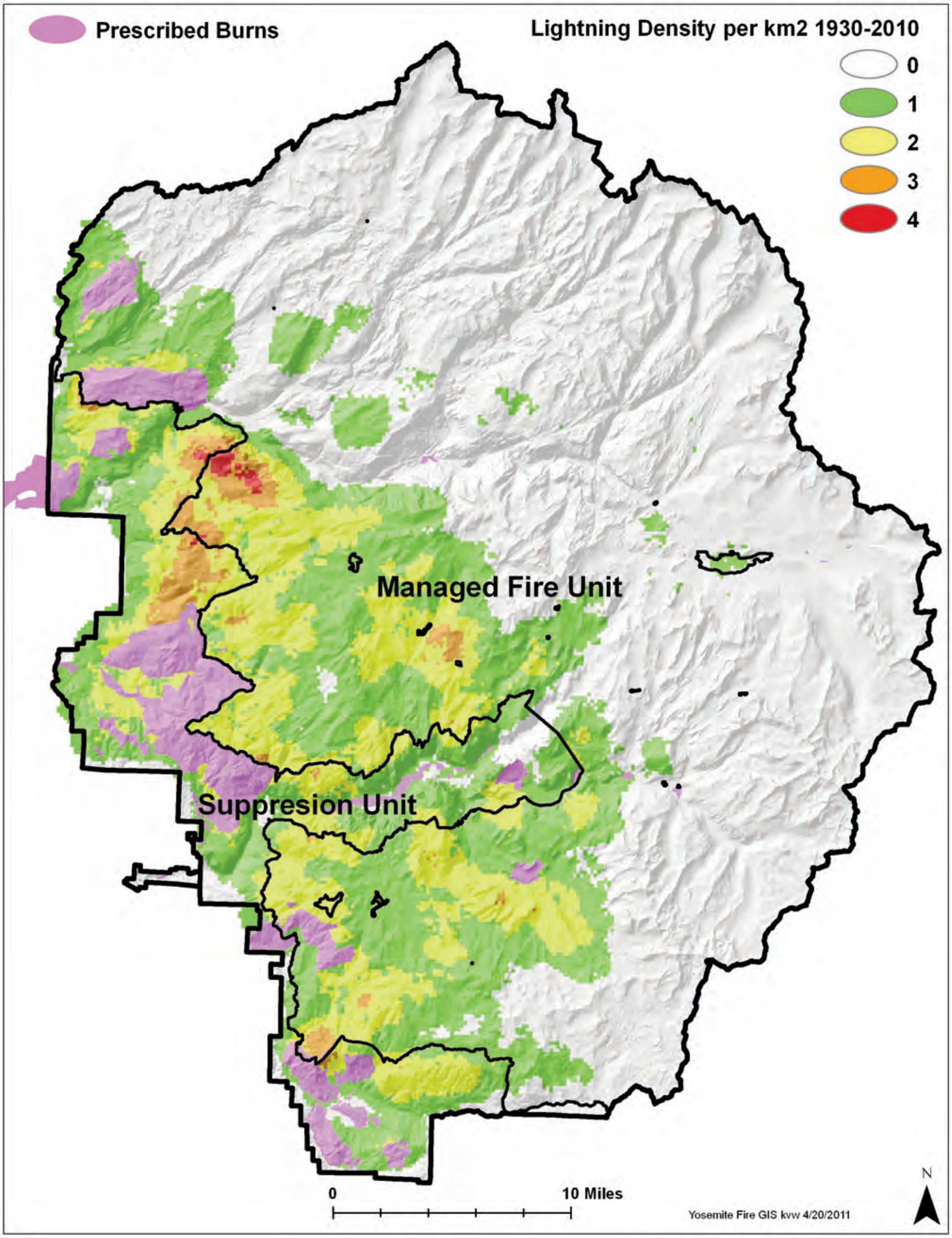

Figure 3. Lightning fire ignition density and prescribed fire history. Despite the benefit of large prescribed burns, many large burns were completed prior to 2006. In many years when the park is unable to conduct landscape-level burns, the more vulnerable the ecosystem becomes to large, undesired fires.

In these lower elevation areas, the planning efforts would pay off. The park has to be realistic about its able to manage fire in these highly altered landscapes that have a tremendous amount of fuel. Conditions would have to be just right in order to allow fire to burn here. Again, existing infrastructure and previous burn perimeters would need to be identified, to ensure these fires could be managed safely. Under prescriptive parameters for these vegetation types and fuel models, Yosemite could usher in a new era of fire management on both sides of the border.

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